



# MULTI-ROLE ARMAMENT & AMMUNITION SYSTEM (MRAAS) CANNON

*Providing America Advanced Armaments for Peace and War*



A PRESENTATION TO THE  
**NATO RESEARCH AND TECHNOLOGY AGENCY (RTA)**  
**AVT – 108**  
**WEAPONS INTEGRATION WITH LAND AND AIR**  
**VEHICLES – LAND SESSION**

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**ARDEC**

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## BACKGROUND



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- **FUTURE COMBAT SYSTEM (FCS): “THE FUTURE COMBAT SYSTEMS WILL BE A MULTI-FUNCTIONAL, MULTI-MISSION RE-CONFIGURABLE SYSTEM OF SYSTEMS TO MAXIMIZE . . . TRANSPORTABILITY AND COMMONALITY OF MISSION ROLES INCLUDING DIRECT AND INDIRECT FIRE, AIR DEFENSE, RECONNAISSANCE, TROOP TRANSPORT, . . .**
- **MRAAS: MULTI-ROLE ARMAMENT SYSTEM IS TECH BASE DEVELOPMENT OF AN ARMAMENT SYSTEM TO PROVIDE BOTH DIRECT AND INDIRECT FIRE CAPABILITIES FOR FCS**
- **BLOS: BEYOND LINE OF SIGHT, LOS: LINE OF SIGHT**
- **STO: SCIENCE & TECHNOLOGY OBJECTIVE**
- **TRL: TECHNOLOGY READINESS LEVEL**
- **MAST: MCS AMMUNITION SYSTEM TECHNOLOGY**
- **ETI/ETC: ELECTROTHERMAL IGNITION/ELECTROTHERMAL-CHEMICAL**

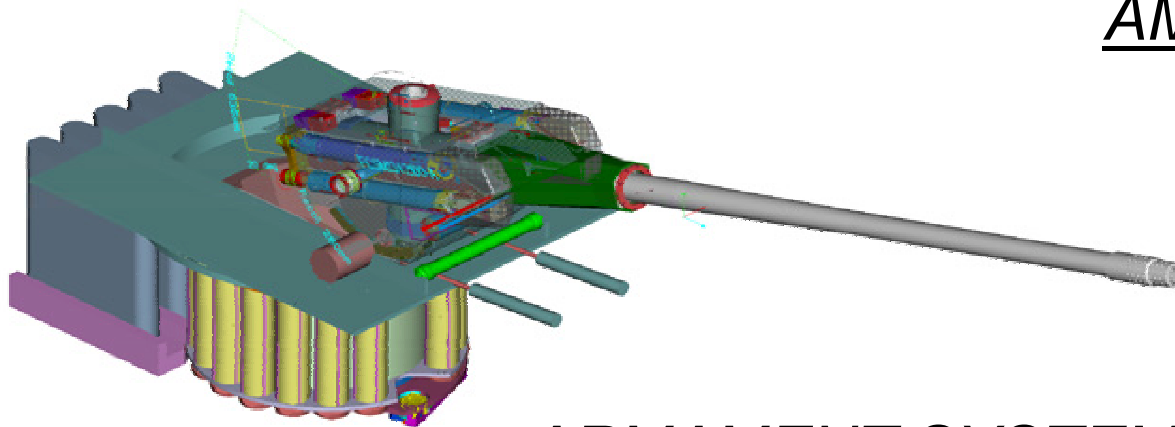


# PROGRAM OBJECTIVES FCS-MRAAS



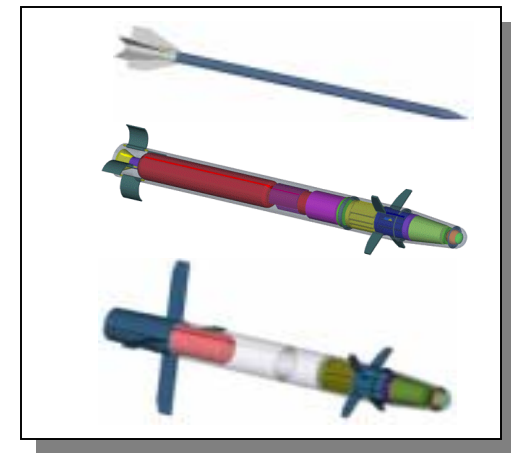
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- ASSIST THE U.S. ARMY IN DETERMINING MATERIAL NEEDS AND ASSOCIATED REQUIREMENTS FOR ITS FUTURE COMBAT SYSTEM (FCS)
- IDENTIFY AND ADVANCE PACING ARMAMENT & AMMUNITION TECHNOLOGIES THAT WILL HELP MEET FCS MATERIAL NEEDS AND REQUIREMENTS



ARMAMENT SYSTEM

## AMMUNITION SUITE





## SYSTEM DESIGN - AMMUNITION



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- **DEVELOPED A CASED TELESCOPING APPROACH (BY PICATINNY & ARMTEC)**
  - **ALLOWS EASY AUTOLOADING & HANDLING**
  - **NO NEED FOR ZONING SINCE SMART PROJECTILE & GUN POINTING WILL ALLOW FOR RANGE CORRECTION AND MRSI MISSIONS.**





# SYSTEM DESIGN - AMMUNITION



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- **ALSO EXAMINED INNOVATIVE INTEGRATION APPROACHES (PICATINNY & ARMTEC)**
  - **COMBINE PACKAGING AND CARTRIDGE INTO A RECYCLABLE, AUTOLOADABLE, ENVIRONMENTAL UNIT**
  - **OPTIONAL APPROACH WOULD BE TO UTILIZE A COMBUSTIBLE CASE AND SEPARATE CONTAINER**
  - **SEALS INTEGRATED WITH END CAPS**





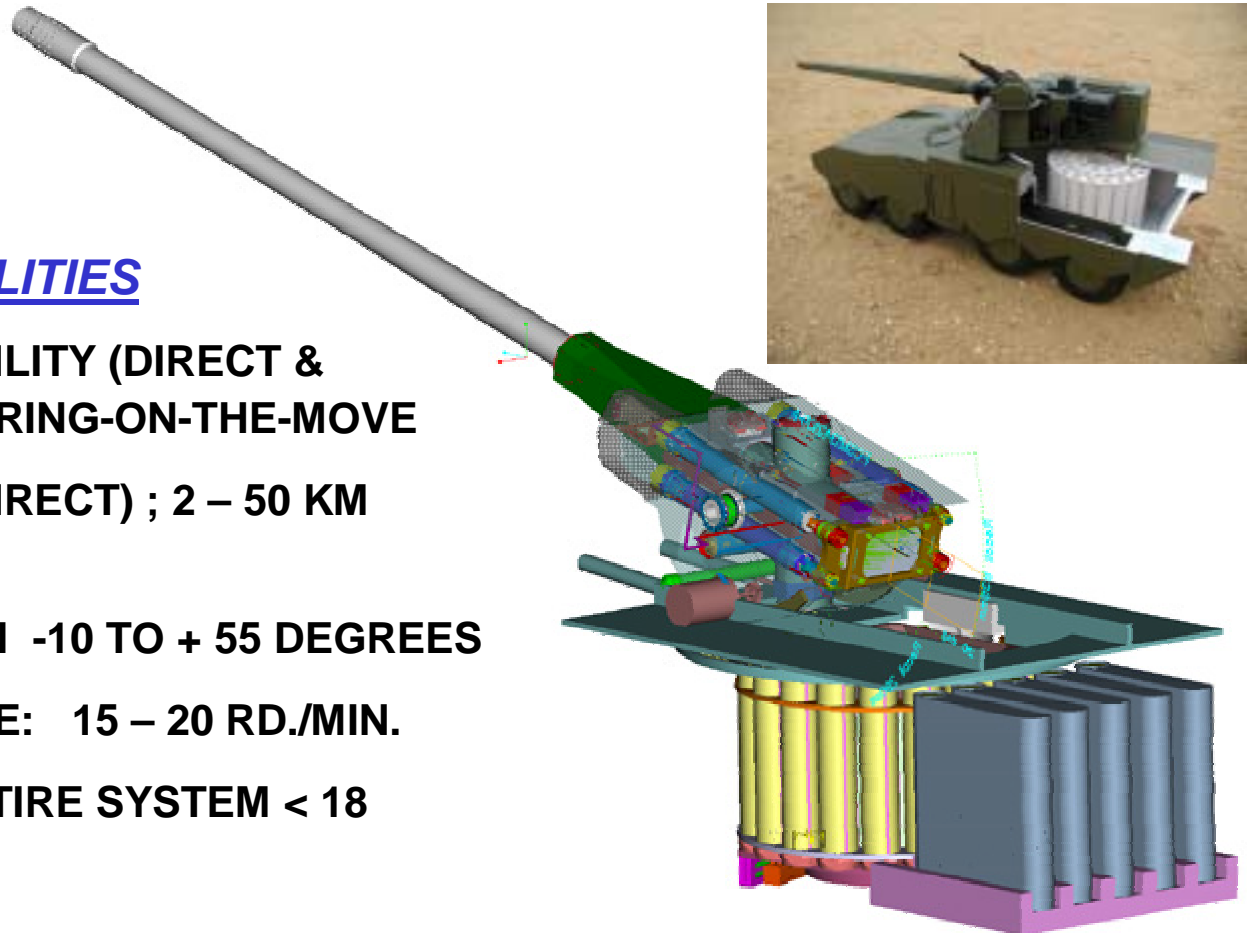
# MRAAS - OVERALL CONCEPT



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## KEY SYSTEM CAPABILITIES

- MULTI-ROLE CAPABILITY (DIRECT & INDIRECT), WHILE FIRING-ON-THE-MOVE
- RANGE: 0 - 4 KM (DIRECT) ; 2 – 50 KM (INDIRECT)
- CANNON ELEVATION -10 TO + 55 DEGREES
- BURST RATE OF FIRE: 15 – 20 RD./MIN.
- LIGHTWEIGHT (ENTIRE SYSTEM < 18 TONS)

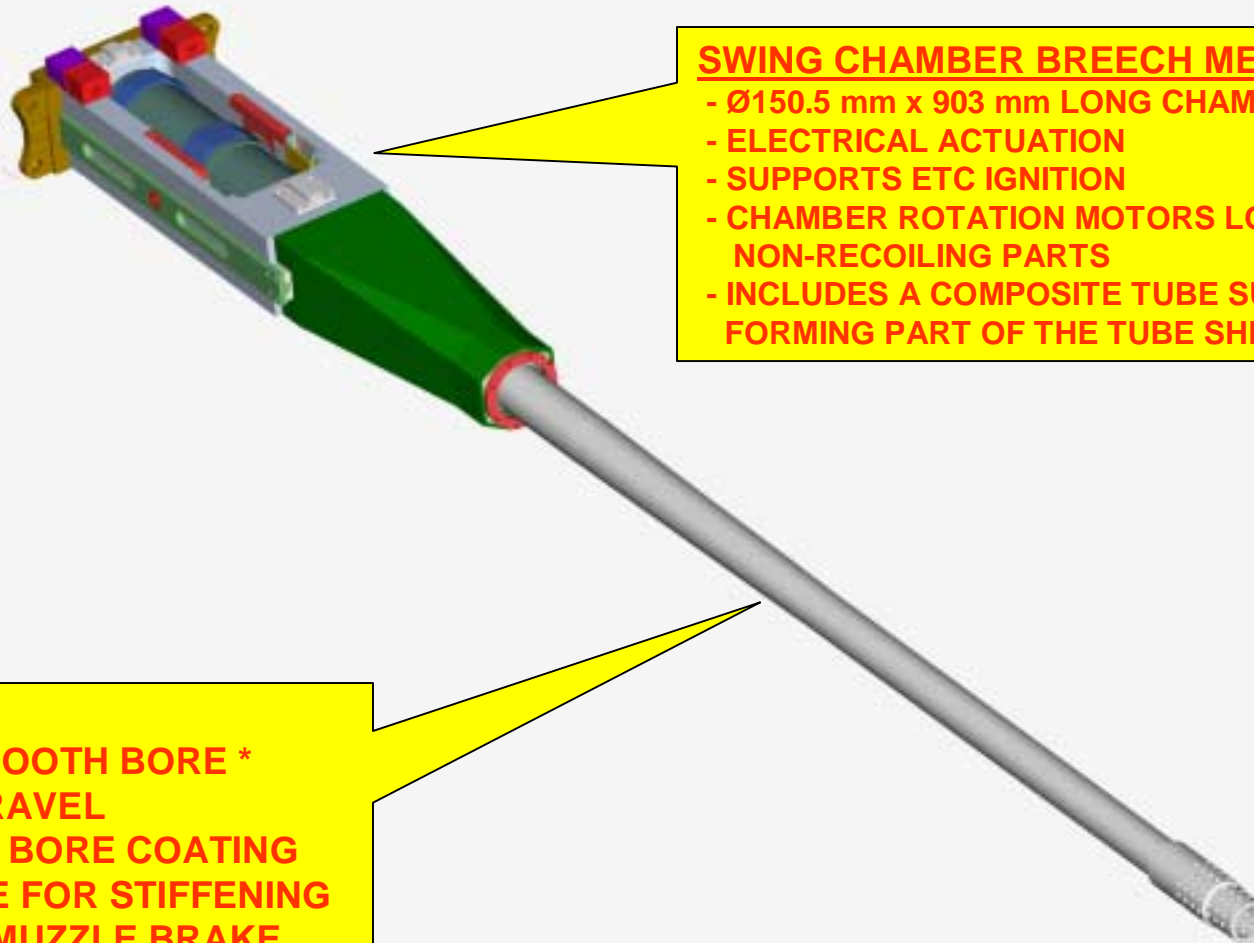




# SYSTEM DESIGN - OVERALL LAUNCHER



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## SWING CHAMBER BREECH MECHANISM

- Ø150.5 mm x 903 mm LONG CHAMBER
- ELECTRICAL ACTUATION
- SUPPORTS ETC IGNITION
- CHAMBER ROTATION MOTORS LOCATED ON NON-RECOILING PARTS
- INCLUDES A COMPOSITE TUBE SUPPORT FORMING PART OF THE TUBE SHROUD.

## GUN TUBE

- 105 mm SMOOTH BORE \*
- 5400mm TRAVEL
- ADVANCED BORE COATING
- COMPOSITE FOR STIFFENING
- INTEGRAL MUZZLE BRAKE

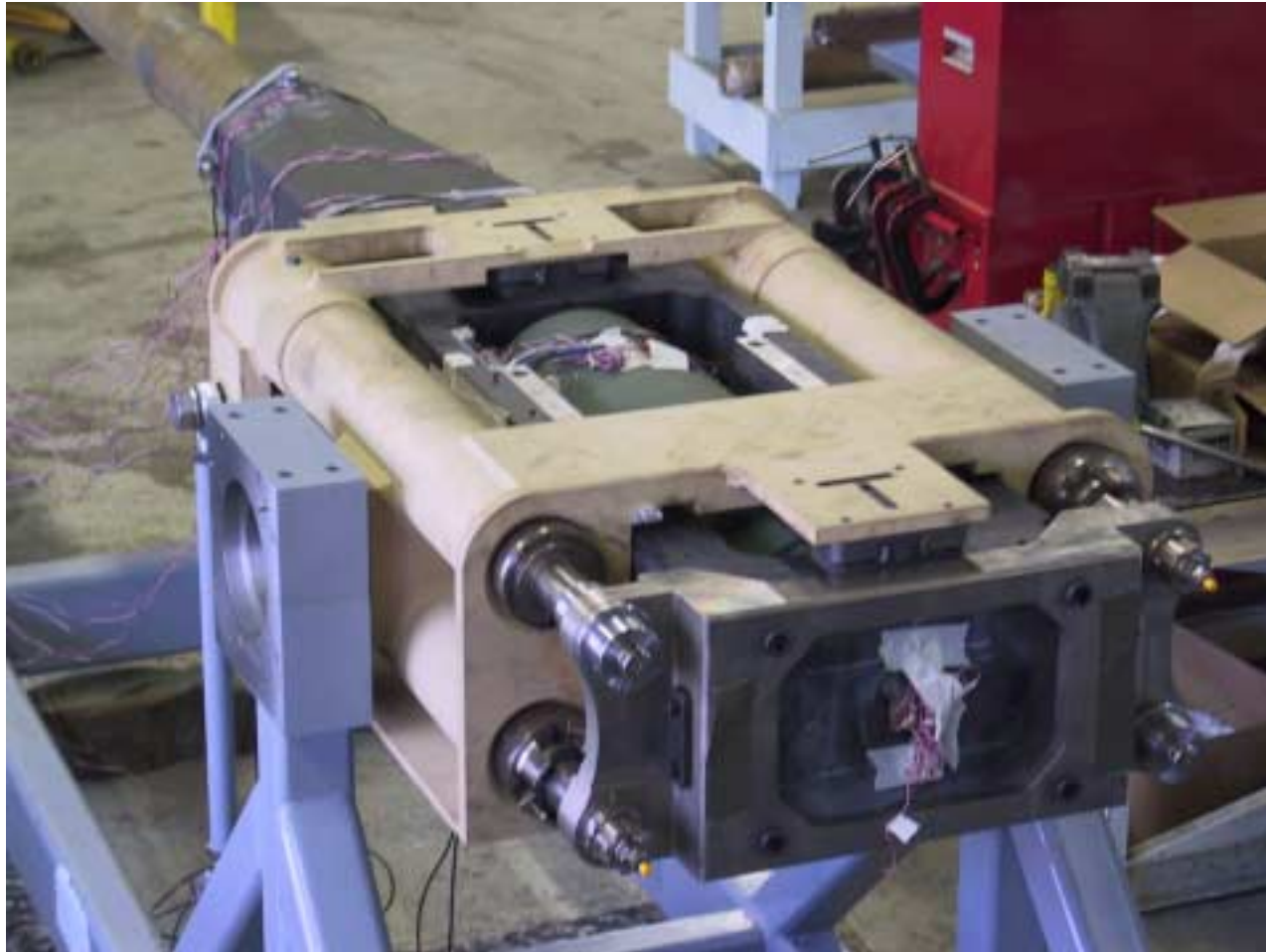




# OVERALL SYSTEM CONCEPT



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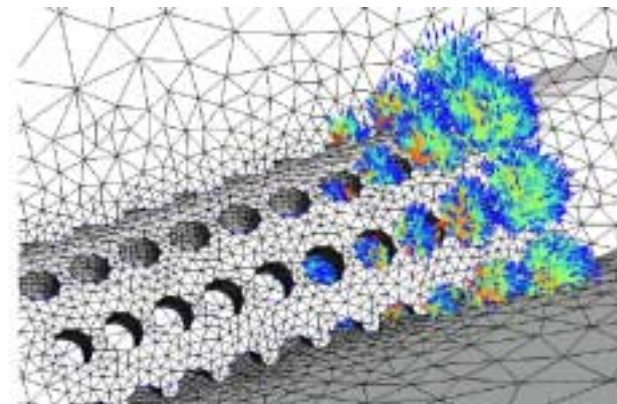


# KEY TECHNICAL THRUST INTEGRAL MUZZLE BRAKE



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- EXTENSIVE COMPUTATIONAL FLUID DYNAMIC MODELS
- ESTIMATE FORCES AND BLAST FIELDS
- EXAMINED GEOMETRIES TO MINIMIZE EFFECT ON LIGHT VEHICLES
- ALLOW FOR FUTURE DESIGN OF LIGHTWEIGHT SURVIVABILITY SHROUDS



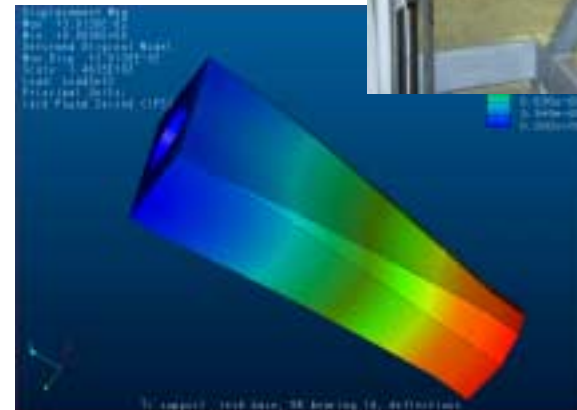


# KEY TECHNICAL THRUST COMPOSITE TUBE SUPPORT



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- **CONCEPT FOR SUPPORT/STIFFENING THE TUBE**
- **DIFFERED FROM COMPOSITE TUBE**
- **UTILIZED TITANIUM END FRAMES AND CARBON FIBER SHELL**
- **SHAPE WAS OPTIMIZED TO BECOME PART OF FUTURE SURVIVABILITY SUITE**
- **UTILIZED PATENTED BENET TUBE INTERLOCK THAT ALLOWS TUBE DILATION WITHOUT RESTRICTION.**



**ASSEMBLY WEIGHT REQUIREMENT 130 LBS - ACTUAL 65 LBS**



## KEY TECHNICAL THRUST COMPOSITE TUBE



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- **15% WEIGHT REDUCTION**
  - SYSTEM LEVEL WEIGHT REDUCTION
  - IMPROVED GUN BALANCE
- **IMPROVED DYNAMIC STRAIN MITIGATION**
- **TUBE STIFFNESS UNCHANGED**
  - DESIGN PARAMETERS INDICATE THAT STIFFNESS CAN BE INCREASED WHILE PRESERVING WEIGHT SAVINGS



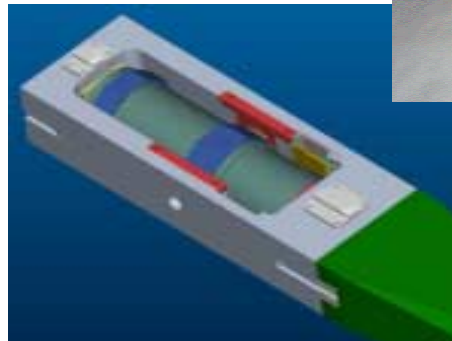
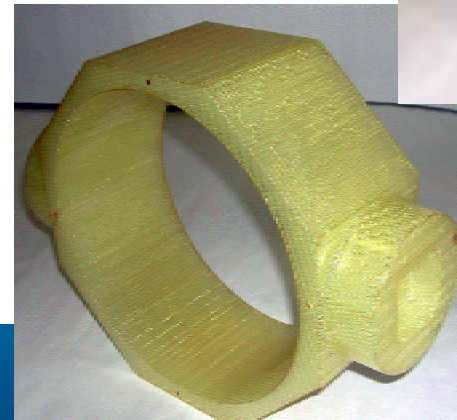


# KEY TECHNICAL THRUST TITANIUM COMPONENTS



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- EXTENSIVE USE OF TITANIUM COMPONENTS TO SAVE WEIGHT.
- INHOUSE TESTING ADDRESSED FATIGUE CHARACTERISTICS OF TITANIUM USED IN STRUCTURAL ELEMENTS
- RAPID PROTOTYPING AND CASTING USED TO SPEED DEVELOPMENT





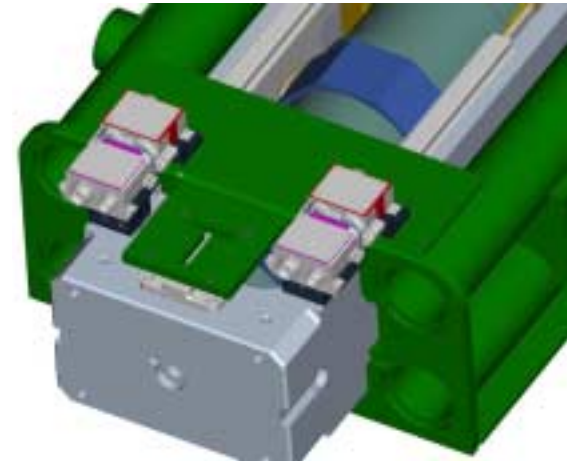


# KEY TECHNICAL THRUST RECOILING ELECTRICAL COMPONENTS



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- **LEVERAGED MAKE BREAK CONNECTORS DEVELOPED FOR CRUSADER AND EXPANDED THE SENSORS AND ELECTRICAL CAPACITY.**
- **UTILIZED COMPACT LINEAR MOTORS FOR BREECH SEAL ACTUATION ON RECOILING BREECH**
- **UTILIZED ROTARY MOTORS TO ADJUST BRAKES FOR VARIABLE RECOIL ON CRADLE**



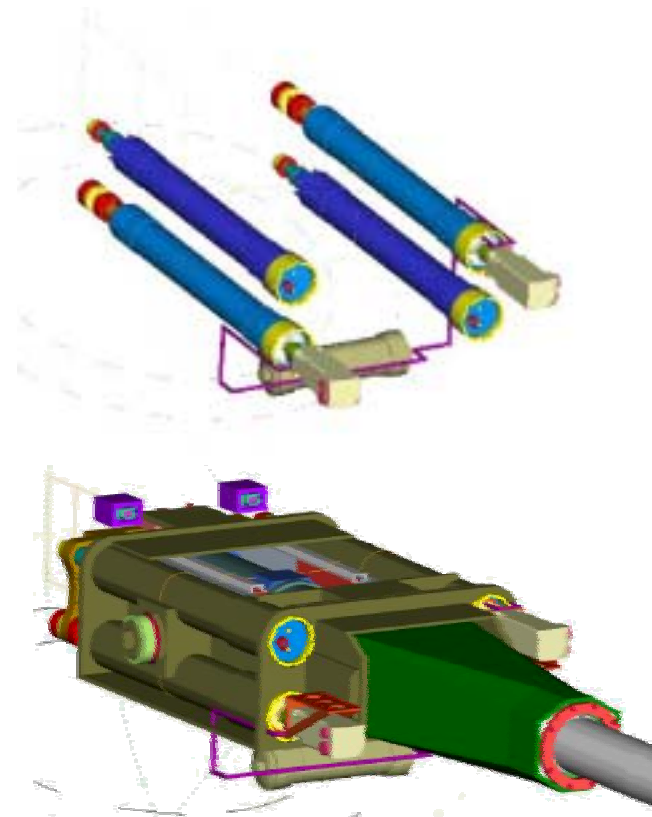


# KEY TECHNICAL THRUST VARIABLE LENGTH RECOIL BRAKES



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- ROTARY ELECTRIC MOTOR ADJUSTED BRAKES TO VARIABLE LENGTH BASED ON ELEVATION AND AMMUNITION
- INDIRECT FIRE @  $-3^{\circ}$  TO  $+55^{\circ}$  ELEVATION
- DIRECT FIRE @  $-10^{\circ}$  TO  $+20^{\circ}$  ELEVATION
- VARIABLE RECOIL (19 & 25 INCHES)
- DEVELOPED AT PICATINNY ARSENAL





## KEY TECHNICAL THRUST HIGH STRENGTH STEEL



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- **NEW HIGH STRENGTH STEEL USED**
  - 10+% INCREASE IN YIELD (165 → 190 KSI)
  - NO DECREASE IN TOUGHNESS
- **FATIGUE TESTING AND ANALYSIS CONDUCTED ON SAMPLES INDICATE GOOD PERFORMANCE IN CANNON ENVIRONMENT**







## **TECHNICAL COMPATIBILITY (NOT DEMONSTRATED)**



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- **ELECTROTHERMALCHEMICAL/ELECTROTHERMAL IGNITION (ETC/ETI)**
- **RAREFACTION WAVE VENTING (RAVEN) COMPATIBLE**
- **FIRE-OUT-OF-BATTERY (FOOB) COMPATIBLE (TESTS CONDUCTED IN EARLY STAGES)**
- **HYBRID MUZZLE BRAKE (EXTERNAL AND INTEGRAL)**
- **SURVIVABILITY/ENVIRONMENTAL SHROUD**
- **ADVANCED BORE COATINGS**

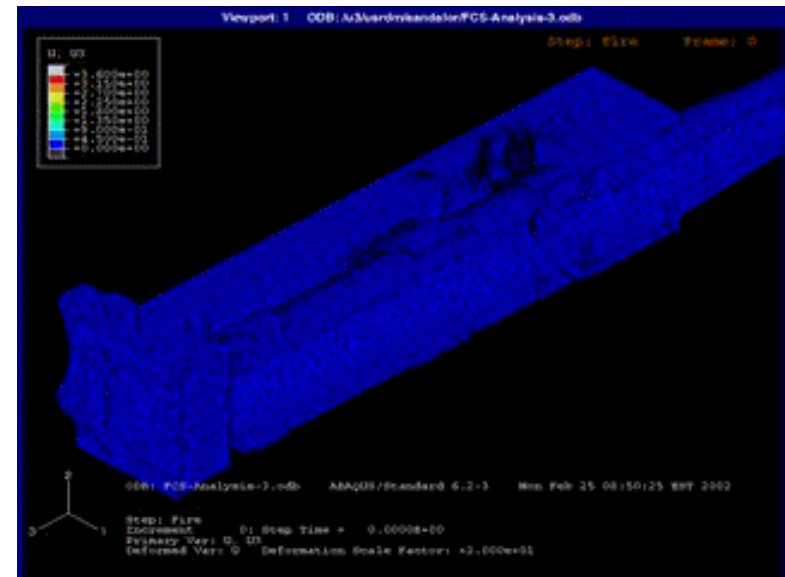


# EXTENSIVE MODELING AND SIMULATION



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- **SHORTENED DEVELOPMENT BY 2-3 YEARS**
- **MODELING INCLUDED:**
  - **FEA OF ALL PRESSURE VESSEL COMPONENTS AND MOUNT STRUCTURE**
  - **NUMERICAL AND FLUID DYNAMICS OF MUZZLE BRAKE**
  - **MATLAB SYSTEM MODELING OF SWING CHAMBER DYNAMICS**
  - **NUMERICAL ANALYSIS OF BRAKE AND RECUPERATOR MODELS**



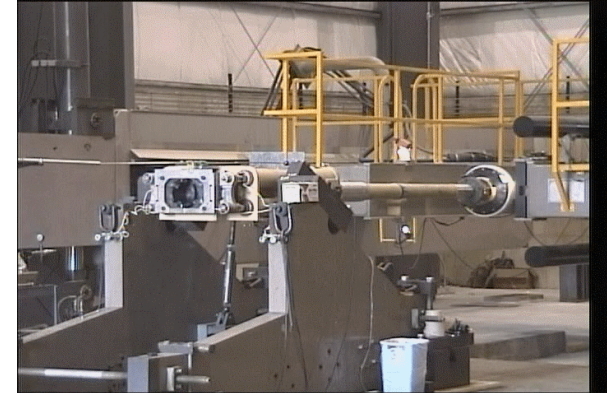


# EXTENSIVE SUB COMPONENT TESTING



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- **COMPLEMENTED MODELING BY VALIDATING KEY RISK ELEMENTS**
- **TESTING INCLUDED:**
  - **CYCLING BREECH TO CONFIRM MECHANICAL ELEMENTS AND SOFTWARE**
  - **PRESSURE TESTING SEALS IN FIXTURES**
  - **DEFLECTION OF TUBE UNDER LOAD**
  - **CYCLING MOUNT SYSTEM IN GYMNASTICATOR**



**TESTING AND MODELING GREATLY REDUCED RISK AND ACCELERATED DEVELOPMENT**

- 
- A photograph of a military launcher system, identified as the FCS-MRAAS, mounted on a tripod and elevated by a crane. The launcher is a long, cylindrical tube with a perforated muzzle. Two men are standing near the base of the launcher, one in a red shirt and one in a dark shirt. The background is a large, tan-colored wall with a rusted metal structure above it. The ground is covered with sandbags and a concrete block.
- **FCS-MRAAS LAUNCHER FIRING DEMO – SPRING '03**
  - **11 ROUNDS FIRED AT ABERDEEN PROVING GROUNDS**
  - **BOTH DIRECT AND INDIRECT FIRE MODE DEMONSTRATED**



## TEST FIRINGS IN DIRECT MODE



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- **OVER 90 CHANNELS OF DATA COLLECTED**
- **MUZZLE VELOCITY AND PEAK PRESSURE PREDICITONS CONFIRMED DURING TEST**









# TEST FIRING IN INDIRECT MODE



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- **CONFIRMED PROJECTED MUZZLE VELOCITY AND RANGE**
- **TUBE DEFLECTION AND WHIP EXAMINED**
- **BLAST OVERPRESSURE FIELD MEASURED**



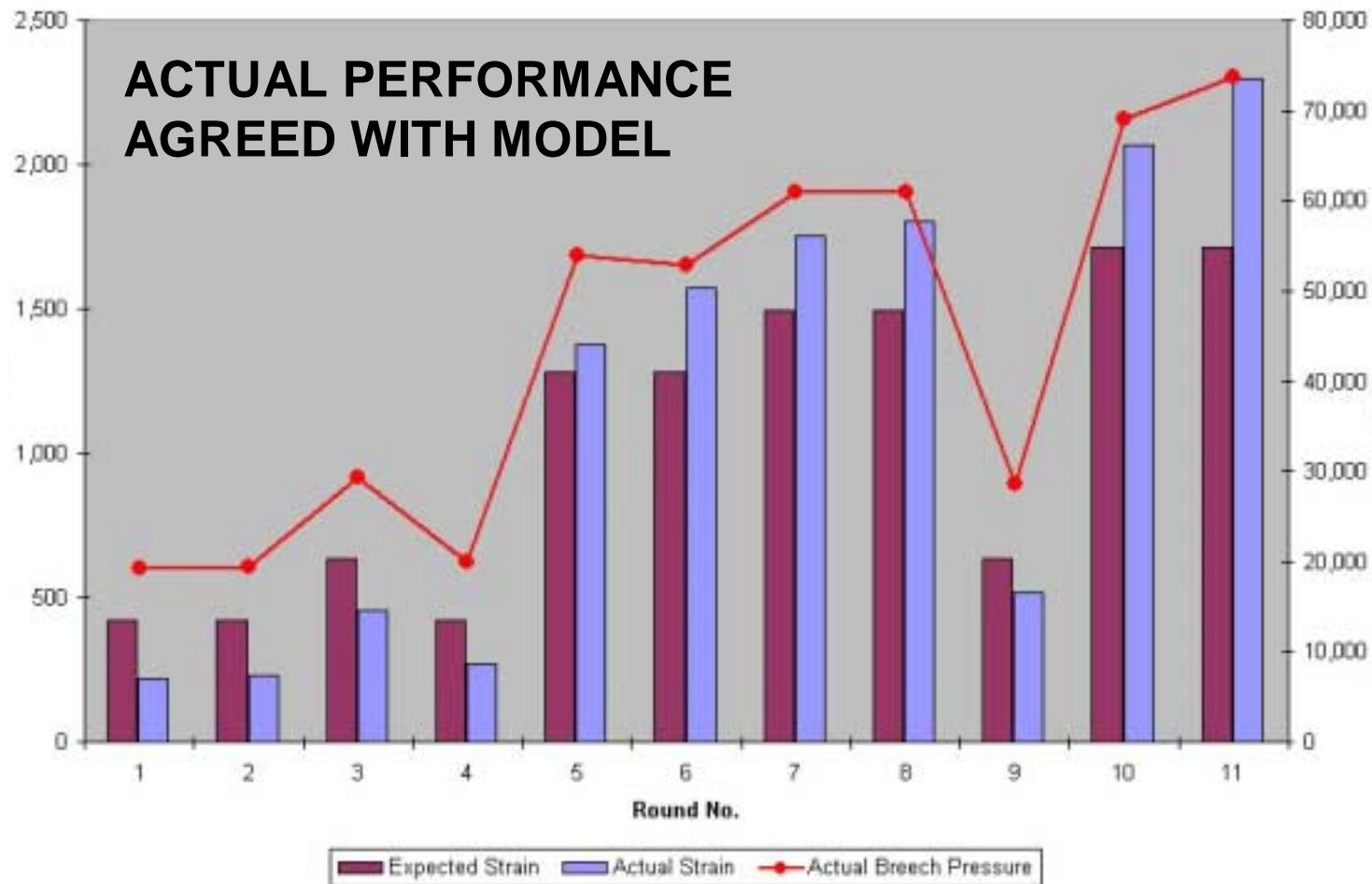


# TEST RESULTS – BREECH SIDE STRAIN



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Breech Forward Side Strain vs. Pressure





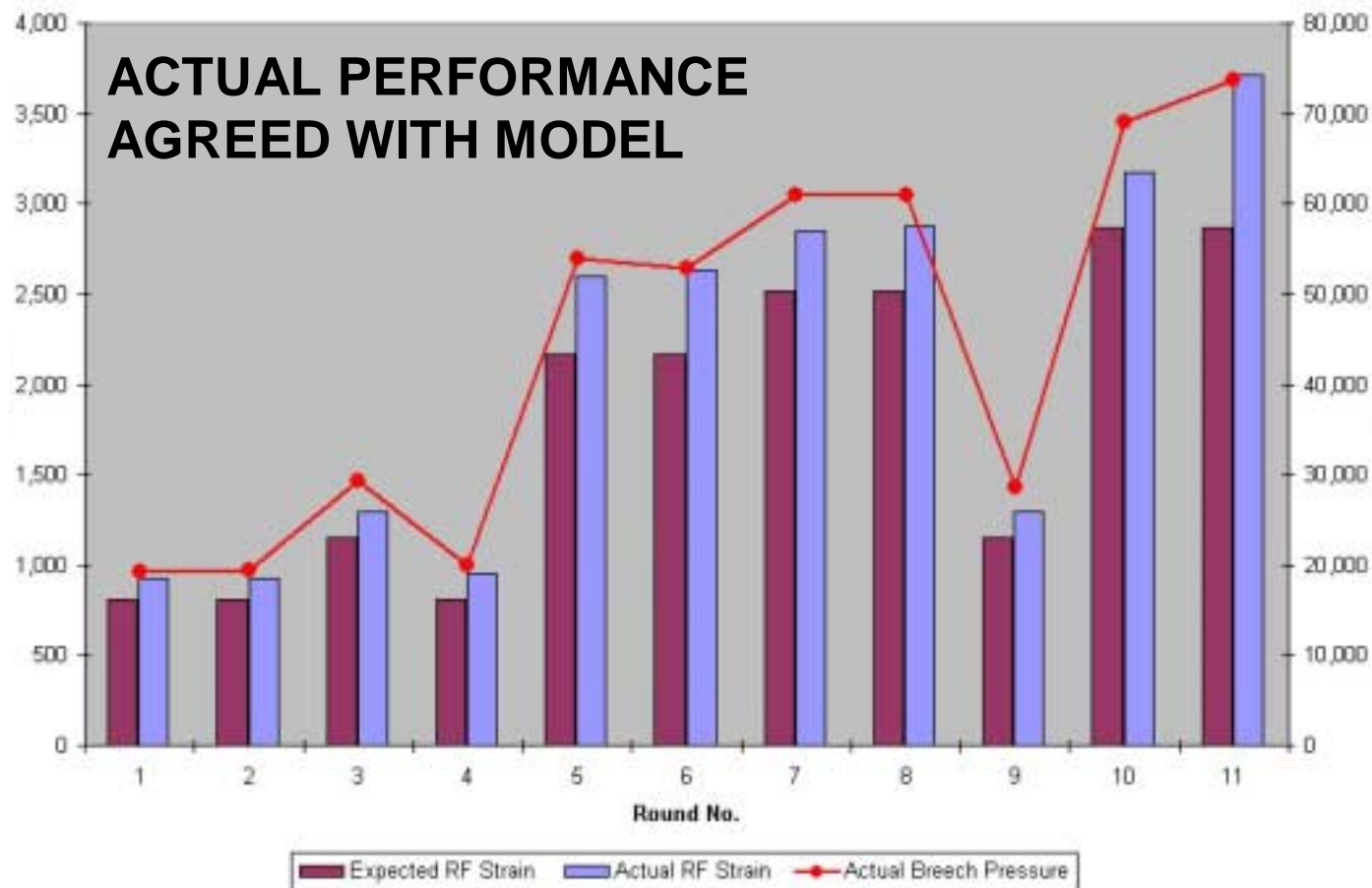



# TEST RESULTS – BREECH REAR STRAIN



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Breech Rear Face Strain vs. Pressure



- 
- **MULTI ROLE ARMAMENT & AMMUNITION SYSTEM TECHNOLOGY PROGRAM SUCCESSFULLY DEMONSTRATED**
    - MUZZLE VELOCITY TO ATTAIN 2-50 KM RANGE
    - LARGE CALIBER SWING CHAMBER CANNON CONFIGURATION
    - LARGE CALIBER CASED TELESCOPED AMMUNITION
    - 3RD GENERATION COMPOSITE WRAPPED TUBE
    - TITANIUM AND COMPOSITE STRUCTURAL ELEMENTS
    - HIGH STRENGTH STEEL
    - INTEGRAL MUZZLE BRAKE
    - RECOILING LINEAR MOTORS

## Multi-Role Armament & Ammunition System (MRAAS) Cannon

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